Barley Response to Planting Rate in Northeastern North Dakota

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Barley, (*Hordeum vulgare* L.), is a major small grain crop in northeastern North Dakota. One important aspect of barley production is the establishment of plant stands that are adequate to ensure optimum yields.

Several studies on planting rate effects on barley yields have been conducted. Guitard et al. (3), in Alberta, Canada, found that planting rates for optimum barley yields ranged from 2.0 to 3.5 bushels per acre. Higher optimum planting rates generally were associated with locations that had reduced emergence because of soil crusting. Finlay et al. (2), in Ontario, Canada, reported no significant differences in planting rates ranging from 1 to 2 bushels per acre.

Young and Bauer (4) found a 1.7 bushel per acre planting rate resulted in significantly higher yields and lower test weights than a 0.8 bushels per acre planting rate in southeastern North Dakota.

Ciha (1), in a four-year study in Washington, reported that a planting rate of 0.75 bushels per acre tended to have the lowest grain yield as compared to 1.4 and 2.0 bushels per acre planting rate across the five cultivars studied. Optimum grain yield generally was obtained at the 1.4 bushels per acre planting rate although differences between other planting rates were not always significant. Reductions in yields at the highest planting rate often were associated with increased lodging.

Although there have been many studies conducted on barley planting rate effects on yield, many fail to take into account percent emergence effects on final stand establishment. The objectives of this study were to i) evaluate planting rate effects on yield and other agronomic traits of barley in northeastern North Dakota and ii) study the relationship between established plant population and yield to determine the minimum number of plants per square foot needed to obtain maximum yields.

Trials were located across northeastern North Dakota at six locations in 1985 and five locations in 1986. Trials were grown near Cavalier, Walhalla, Park River, Lakota, Tolna, Rock Lake, Cando and at the Langdon Research Center.

Trials were planted with a plot seeder in a randomized complete block design with four replications. Depth bands on double disk openers regulated seed depth at 1½ to 2 inches. Seven 6-inch spaced rows 16 feet long were harvested for grain yield. Planting rates for the trials are given in Table 1.

Table 1. Barley planting rates for trials conducted in northeastern North Dakota in 1985 and 1986.

----------------Planting rate[1]----------------			
Million seeds/a	lbs/a	bu/a	Live seeds/ft²
0.5	45	0.9	11
1.0	90	1.9	23
1.5	135	2.8	34
2.0	180	3.8	46

[1]Planting rate adjusted for percent germination and seed size. Thousand kernel weight = 41 grams (11,000 seeds per pound)

Stand counts from each plot were taken after emergence to determine established plant population and percent emergence at all locations except Langdon in 1985 and Park River in 1986. Two random 1-yard lengths were counted in each plot. Carboxin + Thiram treated foundation grade 'Robust' barley seed was used in all trials. The thousand kernel weight of the barley seed was 41 grams (11,000 seeds per pound).

The average planting date for the 1985 and 1986 trials was May 3 and May 12, respectively. Fertility was adequate for a yield goal of 100 bushels per acre or greater at all locations. Soil series and their classifications are listed in Table 2. Weeds were controlled by the use of herbicides and hand weeding. The plots were harvested with a small plot combine. Samples were dried, cleaned, and weighed for yield and test weight. Percent plump kernels and grain protein were also determined. Results from the two-year study were analyzed by treating individual locations and years as separate environments.

Results and Discussion

Temperature averages and precipitation totals for each location are given in Table 3. The 1985 growing season was cool and wet across northeastern North Dakota allowing for excellent barley development. Seedbed moisture was limited at all locations at planting, except at Walhalla and Park River, which resulted in lower percent emergence. The 1986 growing season began with high temperatures and little precipitation in late May. This resulted in dry seedbeds which caused spotty emergence, especially at Tolna and Cavalier. Precipitation amounts across northeastern North Dakota were quite variable in June with only Langdon receiving normal amounts. July precipitation was above normal at all locations. Barley disease levels were low both years.

Table 2. Soil series and their classifications for trial locations in 1985 and 1986.

Soil Series	Location	Year	Classification
Bearden silt loam	Park River	1985	Fine-silty, mixed, frigid Aeric Calciaquolls
Embden fine sandy loam	Walhalla	1985	Coarse-loamy, mixed, Pachic Udic Haploborolls
Emrick loam	Lakota	1985	
	Tolna	1986	
Glyndon loam	Cando	1986	Coarse-silty, frigid Aeric Calciaquolls
	Cavalier	1986	
	Park River	1986	
Heimdal loam	Garske	1985	Coarse-loamy, mixed Udic Haploborolls
Svea loam	Langdon	1985	Fine-loamy, mixed Pachic Udic Haploborolls
	Langdon	1986	
	Rock Lake	1985	

Table 3. Climatological data for May thru August of 1985 and 1986 growing seasons at eleven environments across northeastern North Dakota.[1]

	1985		1986	
Location	**Precip.**	**Avg. Temp.**	**Precip.**	**Avg . Temp.**
	(in.)	(°F)	(in.)	(°F)
Langdon	16.20	58.6	12.29	60.9
Walhalla	14.03	59.7	—	—
Cavalier	—	—	10.84	62.6
Park River	11.82	63.9	12.14	66.0
Lakota	12.41	61.3	—	—
Tolna	—	—	10.2	64.3
Garske	9.07	62.1	—	—
Cando	—	—	9.12	63.4
Rock Lake	13.45	59.6	—	—

[1]Climatological Data of North Dakota 1985-1986. National Oceanic and Atmospheric Administration. Precipitation and temperature obtained from the nearest reporting station to each location.

Agronomic Characteristics

Planting rate effects on plant height averaged across eight environments were non-significant. However, a significant environment by planting rate interaction did occur. Significant differences in plant height across planting rates occurred at five of the seven environments observed. Lakota and Langdon, in 1985 and 1986 respectively, had the highest plant height at the 2.0 million seeds per acre planting rate (Table 4). Cavalier and Park River in 1986 had the lowest plant height at the 2.0 million seeds per acre planting rate. Tolna in 1986 had the lowest plant height at the 1.5 million seeds per acre planting rate. The difference between the highest and the lowest plant height, when averaged across the eight environments, was only 0.4 inches.

Percent protein was determined on barley samples from each planting rate replication at 10 environments. No significant differences in percent protein among planting rates were found. When averaged across environments the 0.5, 1.0, 1.5 and 2.0 million seeds per acre planting rate had a percent protein of 14.1, 14.0, 13.9, and 14.0 percent, respectively. The largest percent protein difference observed across planting rates at one environment was 0.8 percent.

The effect of planting rate on days to head averaged across five environments was significant. There was also a significant environment by planting rate interaction which was due to the magnitude of differences in the number of days to head from planting across environments, not to the effects of planting rates. When averaged across the five environments, the 0.5 million seeds per acre planting rate was significantly later in heading than the other planting rates (Table 5). The

Table 4. Planting rate effect on barley plant height across eight environments during the 1985 and 1986 growing seasons in northeastern North Dakota.

	1985				1986				
Planting Rate	Langdon	Lakota	Garske	Rock Lake	Langdon	Cavalier	Park River	Tolna	Mean
Million seeds/a	Inches								
0.5	40.9	30.1	35.0	41.9	29.0	30.5	30.1	25.5	32.9
1.0	41.2	31.5	34.3	40.5	28.9	31.4	30.0	24.3	32.8
1.5	41.3	31.3	35.6	41.5	29.1	29.9	28.7	22.8	32.5
2.0	40.3	31.9	35.8	41.3	30.6	29.7	28.0	23.0	32.6
LSD 5%					1.7				NA[1]

[1]NA — LSD 5% not valid for mean values.

number of days to head from planting generally decreased with increasing planting rates.

Lodging was observed in two environments during the two-year study. The 0.5 million seeds per acre planting rate had a significantly lower lodging score than the three higher planting rates (Table 5). Decreases in yield, however, were not correlated with lodging (R=-0.02, P=0.05). This may have been caused by moderate lodging levels and its occurrence late in the growing season.

Significant differences for percentage of plump kernels occurred at six of the 11 environments (Table 6). The difference across planting rates at the eleven environments ranged from 1 to 22 percent. When averaged across all environments the lowest planting rate had 95 percent plump kernels and decreased with higher planting rates to 90 percent plump kernels at the 2.0 million seeds per acre planting rate.

No significant test weight response to planting rate was observed across the 11 environments. However, a significant environment by planting rate interaction did occur. Test weight was generally the highest at the lowest planting rate in environments where significant differences occurred except at Langdon in 1985 and 1986 where the highest test weight occurred at the 2 million seeds per acre planting rate (Table 7).

A significant yield response to planting rates occurred across the 11 environments studied (Figure 1). The 0.5 million seeds per acre planting rate yielded significantly less than all other planting rates. The highest yield occurred at the 1.5 million seeds per acre planting rate. There was, however, no significant difference in yield between the 1.0, 1.5, and 2.0 million seeds per acre planting rates.

Table 5. Planting rate effect on days to head from planting and lodging of barley across several environments during the 1985 and 1986 growing seasons in northeastern North Dakota.

Planting Rate	Days to head from planting[1] Five location average	Lodging Two location average
Million seeds/a	(days)	(0-9)
0.5	61.9	1.0
1.0	61.0	3.6
1.5	60.6	4.6
2.0	60.6	5.5
LSD 5%	0.5	2.1

[1]Average of Langdon, Cavalier and Tolna in 1985 and Langdon and Park River in 1986.
[2]Scale - 0=no lodging, 9=flat on ground. Average of Cavalier and Park River in 1986.

Stand Establishment

The goal of a producer when selecting a planting rate is to establish a desired target plant population. Percent emergence can have a dramatic affect on final plant population. Predicting percent emergence is virtually impossible because of the many factors involved such as deep seeding, soil crusting, dry seedbeds, herbicide injury, insect damage, or other reasons.

Emergence was evaluated at nine environments in this study. These environments were broken down into categories of environments with adequate seedbed moisture and environments with limited seedbed moisture (based on general observations at planting time). In environments where moisture was adequate at planting (Walhalla and Park River in 1985 and Langdon and Cando in 1986) the percent emergence averaged across planting rates and environments was 77. In environments where moisture was a limiting factor at planting (Tolna, Garske, and Rock Lake in 1985 and Cavalier and Tolna in 1986) the percent emergence averaged across planting rates and environments was 60 (Figure 2). The lower percentage in the dryer environments may have been a result of loose seedbeds at planting which allowed depth bands to penetrate the soil deeper than 2 inches, resulting in deeper seeding. Subsequent rainfall may have caused a soil crust to form, resulting in decreased percent emergence. Percent emergence

Table 6. Planting rate effect on percentage of plump kernels across 11 environments during the 1985 and 1986 growing seasons in northeastern North Dakota.

	1985						1986					
Planting Rate	Langdon	Walhalla	Park River	Lakota	Garske	Rock Lake	Langdon	Cavalier	Park River	Tolna	Cando	Mean
Million seeds/a	Percent[1]											
0.5	96	96	98	85	95	94	95	98	94	94	95	95
1.0	96	94	96	90	83	88	94	95	96	93	95	93
1.5	95	94	95	85	91	91	92	94	95	93	96	92
2.0	92	96	85	68	91	93	93	94	94	93	95	90
LSD 5						4						NA[2]

[1]Percent of seed remaining on top of a 6/64 seive.
[2]NA — LSD 5% not valid for mean values.

Table 7. Planting rate effect on barley test weight across 11 environments during the 1985 and 1986 growing seasons in northeastern North Dakota.

	1985						1986					
Planting Rate	Langdon	Walhalla	Park River	Lakota	Garske	Rock Lake	Langdon	Cavalier	Park River	Tolna	Cando	Mean
Million seeds/a	lbs/bu.											
0.5	46.2	45.9	47.4	46.4	44.1	48.3	45.3	44.4	47.8	45.5	47.5	46.2
1.0	46.0	45.4	46.1	45.4	42.8	47.9	46.2	44.3	46.5	46.0	47.6	45.8
1.5	46.0	45.3	45.9	43.9	44.1	48.3	46.0	44.5	46.3	45.8	45.8	45.7
2.0	47.0	45.6	45.6	42.6	43.2	47.9	46.5	44.1	46.3	45.6	47.4	45.6
LSD 5						0.5						NA[1]

[1]NA — LSD 5% not valid for mean values.

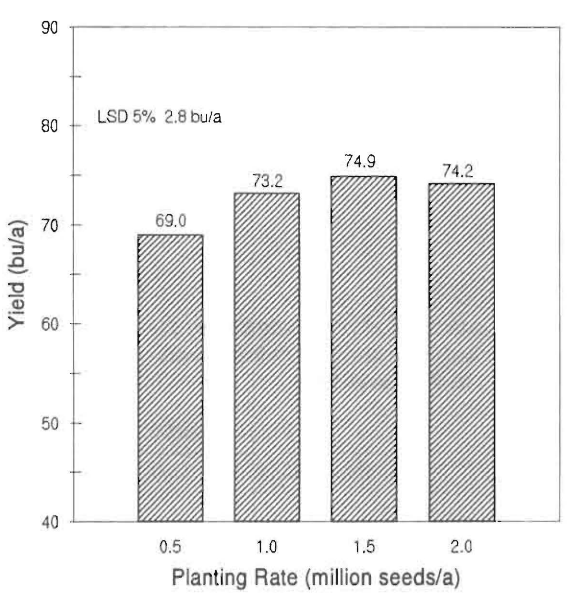

Figure 1. Planting rate effect on barley yield averaged across 11 environments in northeastern North Dakota in 1985-1986.

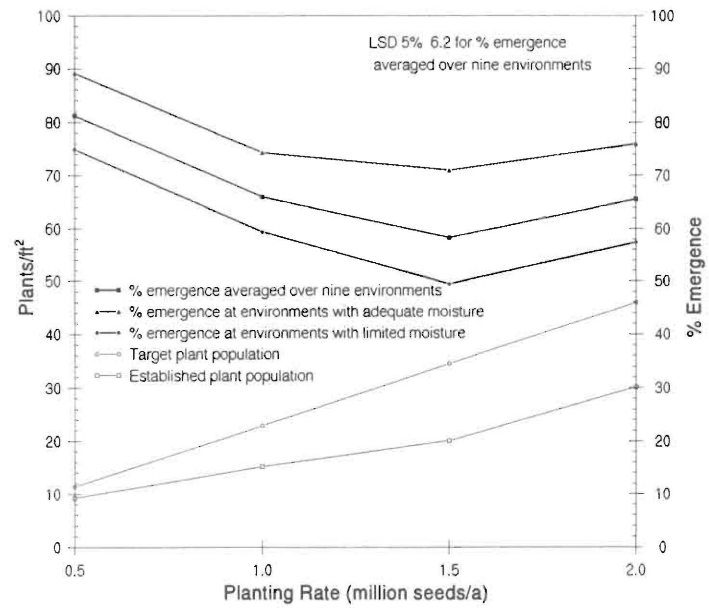

Figure 2. Relationship between target and established plant population and the percent emergence of Robust barley averaged across nine environments in northeastern North Dakota in 1985 and 1986.

responses to planting rates were similar in environments with adequate and limited seedbed moisture. Percent emergence decreased more at the three higher planting rates compared to the 0.5 million seeds per acre planting rate. The decrease may have been due to increased plant competition within the row.

The frequency of various established barley plant populations, for each planting rate, which were within specified plant population ranges are given in Table 8. The 0.5 million seeds per acre planting rate had established plant populations below the minimum required for optimum yields, 17 plants per square foot, in all trials. The 1.0, 1.5, and 2.0 million seeds per acre planting rate had established plant populations above 17 plants per square foot 17, 74, and 89 percent of the time, respectively.

Recommended Seeding Rates

Large differences in percent emergence that can occur from field to field every year makes the selection of the best planting rate difficult. The relationship between established plant population and yield were analyzed in the study to help determine the minimum number of plants per square foot needed to obtain optimum yields. The optimum yield, in this study, occurred at an established plant population of 31 plants per square foot (1.35 million plants per acre) (Figure 3). There was no statistical difference in yield, however, between 17 and 39 plants per square foot (0.74 and 1.7 million plants per acre). This suggests that the minimum established plant population needed to obtain optimum yields would be 17 plants per square foot. No significant yield benefits were obtained with higher established plant populations.

The goal of a producer, then, is to establish a plant population of at least 17 plants per square foot. In this study, a planting rate of 0.96 million seeds per acre (1.8 bushels per acre) with a 77 percent emergence resulted in 17 established plants per square foot in seedbeds with adequate moisture. A planting rate of 1.23 million seeds per acre (2.3 bushels per acre) with a 60 percent emergence resulted in 17 established plants per square foot in seedbeds with limited moisture. Seedbed conditions at planting time in addition to percent germination and seed size will dictate the planting rate that a producer chooses. A favorable seedbed at planting may allow producers to reduce planting rates and still obtain target plant populations.

Established plant populations below 17 plants per square foot may require a replanting decision. Barley has a great ability to compensate for low stands by increased tillering. Figure 3 indicates that replanting at stands as low as 10 plants per square foot may not be a good economic choice. A producer who assumes a yield potential of 60 bushels per acre can expect a yield loss of 4.2 bushels per acre

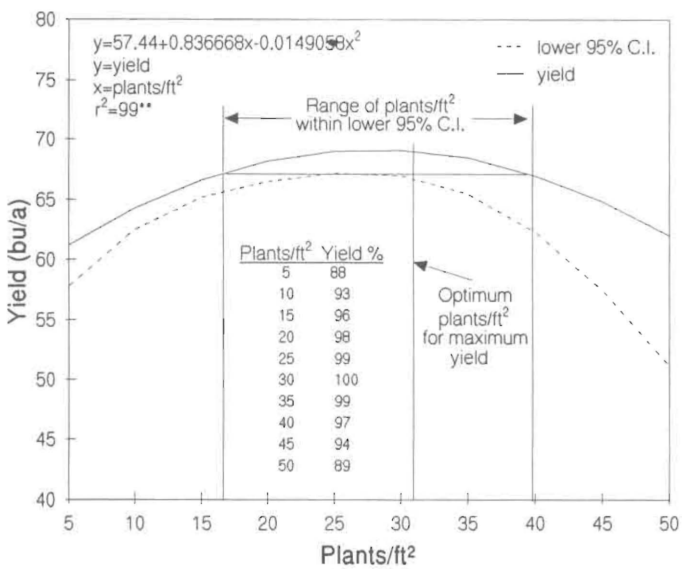

Figure 3. Relationship between plants/ft² and yield of Robust barley averaged across nine environments in northeast North Dakota in 1985 and 1986.

Table 8. Frequencies of observed barley plant populations for each planting rate at nine environments in northeastern North Dakota in 1985 and 1986.[1]

		Established plants/ft²				
		<10	10-16	17-29	30-40	>40
Million seeds/a	Live seeds/ ft²	%				
0.5	11	69	31	0	0	0
1.0	23	3	80	17	0	0
1.5	34	0	23	71	3	0
2.0	46	0	11	49	34	6

[1]17-40 plants/ft² was considered optimum.

(7 percent) at 10 plants per square foot. At $2.00 per bushel this would equal an $8.40 loss per acre. Potential yield loss from late planting (at least a two-week delay), in addition to seed, tillage and labor costs, may easily raise replanting cost above returns. Weed control costs, however, may increase if low plant stands are left. Producers must carefully consider these factors before replanting.

Summary

1. Planting rate effects on plant height, percent protein and days to head from planting were small in this study and should not affect cultural practices by the producer.
2. Lodging was significantly less at the 0.5 million seeds per acre planting rate compared to the 1.0, 1.5, and 2.0 million seeds per acre planting rate. Although lodging was not correlated to yield loss in this study, producers need to be aware that other studies have shown that higher lodging scores can result in yield reductions.
3. Percent plump kernels and test weight response to planting rate varied by environment. Differences in kernel plumpness as a response to planting rate ranged from 1 to 22 percent between environments. The lowest planting rate generally had the highest percentage of plump kernels, although differences between planting rates were not always significant. Test weights generally were highest at the lowest planting rates.
4. Established plant populations of 31 plants per square foot produced optimum yields with no statistical differences in yield occurring between 17 and 39 plants per square foot. This is based on data from stands with very low weed competition.
5. Stand establishment is unpredictable due to environmental effects. Percent emergence can vary from field to field resulting in differences in plant population. The goal of a producer is to establish a plant population of at least 17 plants per square foot. A seed lot with 95 percent germination and 12,000 seeds per pound would require a planting rate of 1.3, 1.4, 1.6, 1.8, and 2.2 bushels per acre at 100, 90, 80, 70, and 60 percent emergence, respectively, to obtain 17 plants per square foot. Seedbed conditions at planting, percent germination and seed size will dictate the planting rate that a producer chooses.

When stand establishment is below 17 plants per square foot careful consideration to yield loss, from delayed planting, in addition to seed, tillage and labor cost must be considered before a replanting decision is made.

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